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Page 3

Robots Find Room for Small Pipelines

By Peter Loftus
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Robots might soon join "pigs" roaming the innards of natural-gas pipelines, searching for damage that could cause a leak or explosion.

Since the 1960s, energy companies have used so-called smart pigs to inspect larger gas pipelines, including interstate transmission lines. No, they aren't clever farm animals. They are heavy-metal vehicles inserted into pipelines, equipped with magnets to detect corrosion and other damage. They are pushed along by the gas pressure, and they are called pigs because they make a squealing sound as they traverse miles of pipeline.

But most smart pigs can't fit into smaller pipes, especially aging distribution mains, and they can't navigate sharp bends. Smart pigs can be used in only about 30% to 40% of all pipes in the U.S., according to Rodney Anderson, a technology manager with the Department of Energy's National Energy Technology Laboratory. To inspect the smaller pipes, utilities have turned to tethered cameras and gas-leak monitoring, but these methods can be costly.

Now, Mr. Anderson and others are developing a remote-control robot to inspect smaller pipelines, which they believe will be more effective than current methods. Named the Explorer, the robot has cameras that can visually inspect the interiors of distribution mains with diameters of six and eight inches. It is battery-powered and wirelessly sends a live image to a laptop computer manned by an operator.

"It's a very attractive option for inspecting virtually all of the pipes in the U.S. in the future," said Mr. Anderson.

The importance of pipeline inspection is underscored whenever pipe damage has disastrous consequences. Since 1986, natural-gas pipeline ruptures, explosions and other incidents in the U.S. have killed more than 370 people and caused more than $750 million in property damage, according to the Department of Transportation's Office of Pipeline Safety.

To inspect distribution mains, utilities have inserted video cameras over the past 15 years. But this method can be costly, mainly because the wired cameras have limited ranges. Few can travel more than 250 feet from where they are inserted, which means workers have to perform numerous excavations.

To address the problem, Mr. Anderson and his colleagues have been working with robotics specialists at Carnegie Mellon University in Pittsburgh and engineers from the Northeast Gas Association, a trade group for gas utilities in the Northeast. Since 2001 the DOE and the Northeast Gas Association together have committed about $2.5 million in funding for two phases of Explorer development.

A primary advantage of Explorer is that it is untethered. In recent field demonstrations, it traveled as far as 1,300 feet from the point of insertion, said George Vradis, an engineering professor at New York's Polytechnic University and project manager for the Northeast Gas Association.

This range could help utilities save money. "If you have to launch [a tethered camera] every 250 feet, it becomes extremely expensive," Mr. Vradis said. "If we were to inspect 2,500 feet of pipeline, the cost of doing that with Explorer would be 35% to 40% less than with conventional tethered cameras."

This could translate into millions of dollars of savings because utilities now spend about $650 million annually to repair pipeline leaks, according to the researchers.

The first version of Explorer, completed last year, is about six feet long and four inches in diameter, Mr. Anderson said. It has miniature fish-eye cameras on either end, which provide a 190-degree field of view and can transmit high-resolution color images of the pipe's interior. It can move at about four inches per second, although it will probably be used at slower speeds during inspections to ensure that operators don't miss anything.

"It will allow us to go over vast sections of pipe in a relatively short time," said Thomas Kiley, president of the Northeast Gas Association. "And if we find there's damage, we can take corrective action before there's an incident involving those pipelines."

A visual inspection of a natural-gas pipeline can reveal corrosion, liquids and even obstacles like rocks, Mr. Vradis said. Corrosion can lead to ruptures, and buildups of water can block the flow of gas to customers. Damage can be caused by frost or nearby construction projects.

Last year, Explorer was tested in live pipelines, both low- and high-pressure, in various parts of New York State, including areas served by **Consolidated Edison** Inc. and **Energy East** Corp. Researchers said the tests showed that Explorer was efficient and safe. In one test, Explorer detected pipes that weren't on the utility's maps.

But a visual inspection can't directly detect thinning of a pipe's wall, which is crucial to finding potential rupture spots. So the researchers are now at work at the next version, Explorer 2, which will include sensors to detect pipe thinning.

The research team will test sensors that use sound waves and magnetic fields to measure pipe-wall thickness, Mr. Vradis said. While the first version of Explorer was designed primarily for distribution mains, the next version could be used in transmission lines as well, Mr. Vradis said. Some transmission lines can't accommodate smart pigs because of sharp turns, but Explorer should be able to get around them.